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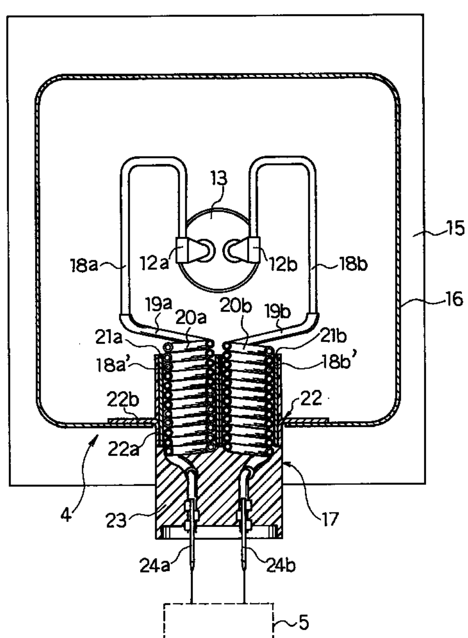
(54) Microwave apparatus

(57) An LC filter member (17) has at least one coil-shaped conductor wire (18a', 18b'), an insulating layer (19a, 19b) formed on the outer surface of the coil-shaped conductor wire (18a', 18b') and a conductive layer (20a, 20b) formed on the outer surface of the insulating layer (19a, 19b). One end of the coil-shaped conductor wire (18a', 18b') is substantially electrically connected to cathode terminal (12a, 12b), and the other end of the coil-shaped conductor wire (18a', 18b') is substantially electrically connected to high frequency electric supply (5). The conductive layer (20a, 20b) is grounded.

FIG. 2



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Description

FIELD OF THE INVENTION AND RELATED ART STATEMENT

1. FIELD OF THE INVENTION

This invention relates to a microwave apparatus which is suitable for use in a microwave oven or the like.

2. DESCRIPTION OF THE RELATED ART

A microwave apparatus uses a magnetron driven by a high frequency electric supply, and works at a fundamental wave, for example 2,450 MHz. The microwave apparatus is required to prevent undesirable external or outward leakage of high frequency radiation including the fundamental wave from a resonant cavity to a cathode of the magnetron.

FIG.10 is a sectional bottom view taken by a sectional plan which is close to the bottom of a conventional microwave apparatus. As shown in FIG.10, a conventional microwave apparatus 100 comprises a conductive shielding metal case 101 for preventing leakage of the high frequency radiation to the surrounding space, and being encircled therein an LC filter circuit 102 for preventing the high frequency leakage through power supply cord. The shielding metal case 101 is mounted underneath a bottom part of the microwave apparatus 100 so as to cover the below-mentioned choke coils 105a, 105b and cathode terminals 103a, 103b disposed on a stem insulator 104 for preventing the high frequency radiation to outside space.

The LC filter circuit 102 comprises choke coils 105a, 105b and a feed-through-type capacitor 106 attached to a side wall of the shielding metal case 101. The choke coils 105a, 105b are made of an annealed copper wire, and connected between the cathode terminal 103a, 103b and central conductors 108a, 108b of the feed-through-type capacitor 106 by a plasma arc welding, respectively. That is, one end of the choke coil 105a is connected to the cathode terminal 103a, and the other end of the choke coil 105a is connected to one end of the central conductor 108a. Similarly, one end of the choke coil 105b is connected to the cathode terminal 103b, and the other end of the choke coil 105b is connected to one end of the central conductor 108b.

The feed-through-type capacitor 106 comprises pipe shaped insulating cases 107a, 107b, the central conductors 108a, 108b, a cylindrical shaped ceramic dielectric element 109, connecting members 110a, 110b, and a grounding plate 111. The insulating cases 107a, 107b are made of an insulating resin such as PBT (poly butylene telephthalate). The insulating cases 107a, 107b are filled with an insulating resin 113 such as an epoxy resin. Thereby, the central conductors 108a, 108b, the ceramic dielectric element 109, the connecting members 110a, 110b and the grounding plate 111 are isolated from each other, and held at the respective predetermined positions in the insulating cases 107a, 107b.

The central conductors 108a, 108b are insulator-coated electrical wire such as a silicone tube wire (i.e. silicone-sheathed conductor wire), and the other ends of the central conductors 108a, 108b are connected to a high frequency electric supply (not shown) via fasten-tabs 112a, 112b, respectively.

The ceramic dielectric element 109 has two through holes for passing the central conductors 108a, 108b. In the axial direction of the ceramic dielectric element 109, electrodes 109a, 109b are disposed on one surface of the ceramic dielectric element 109, and an electrode 109c is disposed on the other surface of the ceramic dielectric element 109 so as to face to the electrodes 109a, 109b across the ceramic dielectric element 109.

The electrodes 109a, 109b are connected to the central conductors 108a, 108b by the connecting members 110a, 110b, respectively. On the other hand, the electrode 109c is connected to the shielding metal case 101 by the grounding plate 111 to be fixed to the side wall of the shielding metal case 101. Thereby, the electrode 109c is grounded.

However, in the conventional microwave apparatus 100, the LC filter circuit 102 is composed of the choke coils 105a, 105b and the feed-through-type capacitor 106 which has a large number of the component parts. Therefore, the LC filter circuit 102 becomes complicated, and the size of the microwave apparatus must be inevitably a large size. Thereby, there is a problem that cost of the microwave apparatus must become high.

OBJECT AND SUMMARY OF THE INVENTION

The object of the present invention is to provide a microwave apparatus that can solve the aforementioned problems.

In order to achieve the above object, a microwave apparatus in accordance with the present invention comprises:

a microwave generating source,

LC filter means for preventing external leakage of high frequency radiation from the microwave generating source, the LC filter means having at least one coil-shaped conductor wire, an insulating layer formed on at least a part of the outer surface of the coil-shaped conductor wire, and a conductive layer formed on at least a part of the outer surface of the insulating layer.

According to the above-mentioned configuration of the present invention, when the high frequency electric power is supplied from the power source for driving the magnetron to the cathode terminals, a predetermined inductance appears at the at least one coil-shaped conductor, and a predetermined capacitance also appears in the insulating layer. Therefore, the LC filter means consisting of the coiled special conductor works as an LC filter circuit without use of hitherto used feed-through-type capacitor of the prior art. Thereby, it is possible to simplify a construction of the LC filter means, and to reduce a size of the microwave apparatus. As a result, cost of the microwave apparatus can be reduced.

While the novel features of the invention are set forth particularly in the appended claims, the invention, both as to organization and content, will be better understood and appreciated, along with other objects and features thereof, from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a cross sectional view showing a microwave apparatus of a first embodiment of the present invention.

FIG.2 is a partial cross sectional view, which is taken on line II - II of FIG.1, showing a bottom part of the microwave apparatus of the first embodiment of the present invention.

FIG.3A is an enlarged explanatory view showing LC filter means of the microwave apparatus of the first embodiment of the present invention.

FIG.3B is a cross sectional view, which is taken on line IIIB - IIIB of FIG.3A, showing the LC filter means of the microwave apparatus of the first embodiment of the present invention.

FIG.4A is a graph showing cold loss obtained from a first test for the microwave apparatus of the present invention, wherein the abscissa is graduated with measurement frequency and the ordinate is graduated with the cold loss.

FIG.4B is the graph showing the cold loss obtained from the first test for a conventional microwave apparatus, wherein the abscissa is graduated with measurement frequency and the ordinate is graduated with the cold loss.

FIG.5 is a graph showing relations between surface temperature of the coil-shaped cathode and number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art, wherein the abscissa is graduated with number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art and the ordinate is graduated with the surface temperature of the coil-shaped cathode.

FIG.6 is a graph showing relations between the inductance and number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art, wherein the abscissa is graduated with number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art and the ordinate is graduated with the inductance.

FIG.7 is an enlarged explanatory view showing LC filter means of a second embodiment of the microwave apparatus of the present invention.

FIG.8 is an enlarged explanatory view showing LC filter means of a third embodiment of the microwave apparatus of the present invention.

FIG.9 is an enlarged explanatory view showing LC filter means of a fourth embodiment of the microwave apparatus of the present invention.

FIG.10 is the sectional bottom view taken by the sectional plan which is close to the bottom of the conventional microwave apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Hereafter, preferred embodiments of a microwave apparatus of the present invention are described with reference to the accompanying drawings.

FIRST EMBODIMENT

FIG.1 is a cross sectional view showing a microwave apparatus of a first embodiment of the present invention.

As shown in FIG.1, a microwave apparatus 1 comprises a magnetron part 2, an external magnetic circuit part 3 for exciting the magnetron part 2, an antileakage part 4 for preventing external leakage of high frequency radiation including a fundamental wave (for example 2,450 MHz), and a high frequency electric supply part 5 (FIG.2) for driving the magnetron part 2.

The magnetron part 2 has an anode cylinder 6, a coil-shaped cathode 7, a pair of frustum-shaped magnetic pole pieces 8, 9, a microwave radiation antenna 10, and a pair of cathode terminals 12a, 12b. The anode cylinder 6 is made of a metal such as copper. The coil-shaped cathode 7 is made of the metal such as thoriated-tungsten, and disposed coaxially with and in the anode cylinder 6. The pair of the frustum-shaped magnetic pole pieces 8, 9 are made of a magnetic material such as iron, and disposed above and under the coil-shaped cathode 7, respectively. One end of the microwave radiation antenna 10 is disposed in a resonant cavity formed in the inner space of the anode cylinder 6. The other end of the microwave radiation antenna 10 is disposed supported at the top part of the microwave apparatus 1 by a ceramic insulator 11. The pair of the cathode terminals 12a, 12b are disposed on a stem insulator 13 in parallel with each other in a vertical (or normal) direction to the sheet of FIG.1.

The external magnetic circuit part 3 has a pair of cylindrical shaped permanent magnets 14a, 14b disposed above and below the frustum-shaped magnetic pole pieces 8, 9, respectively, and a frame-shaped magnetic yoke 15.

The antileakage part 4 has a conductive shielding metal case 16 mounted underneath the bottom part of the frame-shaped magnetic yoke 15, and LC filter means 17 attached to the side wall of the shielding metal case 16.

A configuration of the LC filter means 17 will be elucidated with reference to FIG.2, FIG.3A and FIG.3B. FIG.2 is a partial cross sectional view, which is taken on line II - II of FIG.1, showing a bottom part of the microwave apparatus of the first embodiment of the present invention. FIG.3A is an enlarged explanatory view showing LC filter means of the microwave apparatus of the first embodiment of the present invention. FIG.3B is a cross sectional view, which is taken on line IIIB - IIIB of FIG.3A, showing the LC filter means of the microwave apparatus of the first embodiment of the present invention. In FIG.2, sectional illustrations of the below-mentioned conductive layers 20a, 20b of the LC filter means 17 are omitted for the sake of simplicity of drawings.

As shown by FIG.1 through FIG.3A, the LC filter means 17 comprises a pair of conductors 18a, 18b, a pair of insulating layers 19a, 19b, a pair of conductive layers 20a, 20b, a pair of pipe-shaped conductive members 21a, 21b, a grounding plate 22 and a cylindrical insulating case 23.

The pair of the conductors 18a, 18b are made of a metal wire such as an annealed copper wire and an aluminum wire, and have coil-shaped parts 18a', 18b' respectively. Each of these coil-shaped parts 18a', 18b' is formed by circularly winding the metal wire, which has a diameter between 1mm and 2mm, to a predetermined number of turns. Each diameter of the coil-shaped parts 18a', 18b' is preferably between 5mm and 10mm, and each length of the coil-shaped parts 18a', 18b' is preferably between 15mm and 25mm. The conductors 18a, 18b are connected between the high frequency electric supply part 5 (shown by a broken line of FIG.2) and the cathode terminals 12a, 12b. That is, one end of the conductor 18a is connected to the cathode terminal 12a by caulking or plasma arc welding, and the other end of the conductor 18a is connected to one terminal of the high frequency electric supply part 5 via a fasten-tab 24a. Similarly, one end of the conductor 18b is connected to the cathode terminal 12b by the caulking or the plasma arc welding, and the other end of the conductor 18b is connected to the other terminal of the high frequency electric supply part 5 via a fasten-tab 24b.

Apart from the aforementioned explanation, wherein each of the coil-shaped parts 18a', 18b' is formed by circularly winding the metal wire to a predetermined number of turns, an alternative construction may be such that each of the coil-shaped parts 18a', 18b' is formed by winding the metal wire into one of an oval, a rectangle and a spiral at a predetermined number of turns. Furthermore, apart from connection through the pair of the conductors 18a, 18b having the coil-shaped parts 18a', 18b' respectively, an alternative construction may be such that only one conductor having the corresponding coil-shaped part is used for connection of one of the cathode terminals and a non-coiled conductor is used for connection of the other of the cathode terminals.

The pair of the insulating layers 19a, 19b are made of a resin such as a polyamide resin and a silicone resin, having a property of heat resisting and a withstand voltage, and formed on the outer surfaces of the conductors 18a, 18b by dip-coating so as to coat at least a part of the coil-shaped parts 18a', 18b', respectively. Each thickness of the insulating layers 19a, 19b is preferably between 30 µm and 500 µm.

The pair of the conductive layers 20a, 20b are made of a conductive material such as a silver paste, nickel and copper, and formed on the outer surfaces of the insulating layers 19a, 19b by metal spraying or the dip-coating so as to cover at least a part of the insulating layers 19a, 19b, respectively. The conductive layers 20a, 20b are isolated from the conductors 18a, 18b by the insulating layers 19a, 19b; and the end parts of the conductors 18a, 18b are not covered by the conductive layers 20a, 20b, respectively. That is, each of the conductive layers 20a, 20b is formed on the outer surfaces of the insulating layers 19a, 19b only between the positions shown by arrows "L1" and "L2" of FIG.3A. Each thickness of the conductive layers 20a, 20b is preferably between 20 µm and 30 µm.

Apart from the aforementioned explanation, wherein the conductive layers 20a, 20b are formed on the outer surfaces of the insulating layers 19a, 19b, respectively, an alternative construction may be such that the conductive layers 20a, 20b are formed on the outer surfaces of the insulating layers 19a, 19b so as to only coat one of the outer side and the inner side of the coil-shaped parts 18a', 18b', respectively.

The pair of the pipe-shaped conductive members 21a, 21b are made of the conductive material such as zinc, aluminum and iron, and fixed around the outer surfaces of the conductive layers 20a, 20b by an adhesive or soldering, respectively.

The grounding plate 22 consists of a cylindrical part 22 and a flange part 22b, and is made of the conductive material such as aluminum, zinc end iron. The cylindrical part 22a is mounted around the outer surfaces of the pipe-shaped conductive members 21a, 21b. The flange part 22b is fixed to the side wall of the shielding metal case 16. Thereby, each of the conductive layers 20a, 20b is grounded via the pipe-shaped conductive members 21a, 21b and the grounding plate 22.

The cylindrical insulting case 23 is made of an insulating resin such as an epoxy resin. As shown in FIG.2, the cylindrical insulating case 23 is formed solid by molding containing the coil-shaped parts 18a', 18b'. However, the inside spaces of the coil-shaped parts 18a', 18b' are not filled with the insulating resin leaving the inside space hollow. In the cylindrical insulating case 23, the conductors 18a, 18b, the conductive layers 20a, 20b, the grounding plate 22 and the fasten-tabs 24a, 24b are isolated from each other.

Apart from the above-mentioned explanation, wherein the cylindrical insulating case 23 is formed solid by the molding containing coil-shaped parts 18a', 18b', an alternative construction may be such that the cylindrical insulating case 23 consists of two components namely, an external casing made of the insulating resin such as a PBT (Poly butylene telephthalate) and a PET (Poly ethylene telephthalate) and an insulating resin such as the epoxy resin therein. In such way, other components are disposed in the external casing, and the insulating resin is poured into the external casing in order to isolate these components from each other and hold these components at respective predetermined positions in the external casing.

By the above-mentioned configuration, in the antileakage part 4, predetermined capacitances appear between the shielding metal case 16 and the fasten-tabs 24a, 24b as shown in FIG.3A.

In this first embodiment, when the high frequency electric power is supplied to the magnetron part 2, the LC filter means 17 operates as follows:

(1) Predetermined inductances appear at the coil-shaped parts 18a', 18b' of the conductors 18a, 18b.
(2) Predetermined capacitances appear in the insulating layers 19a, 19b sandwiched between the coil-shaped parts 18a', 18b' of the conductors 18a, 18b and the grounded conductive layers 20a, 20b, respectively.

Thus, the LC filter means 17 serve as an LC filter circuit where required inductances and capacitances appear without use of a feed-through-type capacitor of the prior art. Therefore, it is possible to simplify a construction of the LC filter circuit.

Furthermore, it is not necessary to connect the feed-through-type capacitor to choke coils like the prior art in the shielding metal case 16. Therefore, it is possible that the size of the microwave apparatus 1 becomes small. As a result, cost of the microwave apparatus 1 can be reduced.

Moreover, it is possible to easily perform a connecting process between the cathode terminals 12a, 12b and the conductors 18a, 18b, respectively. For this reason, any members such as choke coils of the conventional microwave apparatus are not disposed near the cathode terminals 12a, 12b.

Since the conductive layers 20a, 20b are connected to the shielding metal case 16 via the pipe-shaped conductive members 21a, 21b and the grounding plate 22, a superior radiation of heat generated at the conductors 18a, 18b and the conductive layers 20a, 20b is achieved.

Since the inside spaces of the coil-shaped parts 18a', 18b' is not filled with the insulating resin, it is possible to substantially stop occurrence of pealing of the conductive layers 20a, 20b out of the above-mentioned insulating resin owing to differences of their thermal capacity and coefficient of thermal expansion. As a result, it is possible to prevent brokendown at the coil-shaped parts 18a', 18b', and improve a reliability of the microwave apparatus.

In the construction of the LC filter means 17, in the case that annealed copper wire is used for the conductors 18a, 18b, it is possible to reduce the electrical loss during the operation of the microwave apparatus.

Furthermore, in the case that the polyamide resin having high dielectric constant is used for the insulating layers 19a, 19b, a large capacitance per area is obtainable, and the insulating layers 19a, 19b can be easily formed on the outer surfaces of the conductors 18a, 18b, respectively. Moreover, in the case that the silver paste is further used for the conductive layers 20a, 20b, the conductive layers 20a, 20b can be smoothly formed on the respective insulating layers 19a, 19b without falling thereon.

A first test result for confirming effects of the present invention will be elucidated with reference to FIG.4A and FIG.4B. FIG.4A is a graph showing cold loss obtained from a first test for the microwave apparatus of the present invention, wherein the abscissa is graduated with measurement frequency and the ordinate is graduated with the cold loss. FIG.4B is the graph showing the cold loss obtained from the first test for a conventional microwave apparatus, wherein the abscissa is graduated with measurement frequency and the ordinate is graduated with the cold loss.

In these first tests, cold attenuation characteristics of the LC filter means 17 are obtained by measuring cold losses at the predetermined high frequency band (for example, 30 KHz --- 3 GHz). The cold attenuation characteristics are of characteristic for attenuation of the high frequency radiation at cold conditions of the microwave apparatus (i.e. non-oscillation condition of the magnetron part 2). The cold losses are measured by a known measuring device connected between the cathode terminals 12a, 12b and the fasten-tabs 24a, 24b.

Furthermore, in order to confirm the technical advantages of the present invention, the cold attenuation characteristic of the LC filter means 17 of the microwave apparatus 1 shown in FIG.1 is compared with that of the LC filter circuit 102 of the conventional microwave apparatus 100 shown in FIG.10.

In the first test, materials and sizes of the LC filter means 17 shown in FIG.2 are as follows:

the conductors 18a, 18b are of "annealed copper wire" (coated with the below-mentioned insulating layers 19a, 19b, respectively);

each diameter of the conductors 18a, 18b is 1.4 mm (including the below-mentioned thickness of the insulating layers 19a, 19b, respectively);

the insulating layers 19a, 19b are of " polyamide resin";

each thickness of the insulating layers 19a, 19b is 30 μm;

the conductive layers 20a, 20b are of " silver paste";

each thickness of the conductive layers 20a, 20b is 20 μm;

each diameter of the coil-shaped parts 18a', 18b' is 6.4 mm; and

each length of the coil-shaped parts 18a', 18b' is 21 mm.

By the above-mentioned construction, the capacitances of the LC filter means 17 are about 500 pF.

In order to easily and accurately compare with the above-mentioned LC filter means 17, the choke coils 105a, 105b of the conventional LC filter circuit 102 shown in FIG.10 are made in the same configuration as the above-mentioned coil-shaped parts 18a', 18b'. That is, the choke coils 105a, 105b are formed by the same annealed copper wire, which has a diameter of 1.4 mm, coated by the polyamide resin having a thickness of 30 μm, each diameter of the choke coils 105a, 105b is 6.4 mm and each length of the choke coils 105a, 105b is 21 mm. Furthermore, the capacitance of the feed-through-type capacitor 106 is selected to about 500 pF.

As shown in FIG.4A and FIG.4B, the cold losses shown by a solid curve 80 are mostly larger than those shown by a solid curve 81 in the high frequency band of 30 KHz --- 3 GHz. That is, the cold attenuation characteristic of the LC filter means 17 is improved from that of the LC filter circuit 102. Thereby, it is confirmed that a practical LC filter circuit can be composed of the LC filter means 17.

A second test result for confirming effects of the present invention will be elucidated with reference to FIG.5. FIG.5 is a graph showing relations between surface temperature of the coil-shaped cathode and number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art. The abscissa is graduated with number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art, and the ordinate is graduated with the surface temperature of the coil-shaped cathode.

In this second test, it is confirmed influence of number of turns of the coil-shaped parts 18a', 18b' to surface temperature of the coil-shaped cathode 7 (FIG. 1) (hereinafter referred to as a "turns influence") by studying relations between surface temperature of the coil-shaped cathode 7 (FIG.1) and number of turns of the coil-shaped parts 18a', 18b'. The surface temperature of the coil-shaped cathode 7 can be measured by a known infrared sensor.

Furthermore, in this second test, test conditions are changed from those of the first test as follows:

(1) Each length of the coil-shaped parts 18a', 18b' and the choke coils 105a, 105b is varied; and each number of turns of the coil-shaped part 18a', 18b' and the choke coil 105a, 105b is varied.

(2) The microwave apparatus 1 and the conventional microwave apparatus 100 are driven by an inverter electric supply at high frequency of 25 KHz.

In FIG.5, a solid line 82 shows a test result of the microwave apparatus 1, and a solid line 83 shows a test result of the conventional microwave apparatus 100.

Furthermore, as shown in FIG.5, when the surface temperature of the coil-shaped cathode 7 is a range of 1,900 K and 2,100 K, there is a drastic effect that the magnetron part 2 operates stably.

As shown in the solid line 82, in the microwave apparatus 1, number of turns to give a stable operation of the magnetron part 2 in the range between 1,900 K and 2,100 K is in a range between about 10 turns and about 23 turns. On the other hand, as shown in the solid line 83, in the conventional microwave apparatus 100, number of turns to give a stable operation of the magnetron in the range between 1,900 K and 2,100 K is in a range between about 5 turns and about 6 turns. That is, in number of turns to give a stable operation, range of number of turn of the present invention is about 13 (= (23-10)/(6-5)) times as large as that of the prior art. As a result, in the present invention, it is possible to reduce the turns influence, and to easily adjust the microwave apparatus.

The main reason of this result will be elucidated with reference to FIG.6. FIG.6 is a graph showing relations between the inductance and number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art. The abscissa is graduated with number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art, and the ordinate is graduated with the inductance.

In FIG.6, a solid line 84 shows a measured result of the inductance to number of turns of the coil-shaped part 18a', 18b', and a solid line 85 shows a measured result of the inductance to number of turns of the choke coils 105a, 105b. As shown in the solid lines 84 and 85, an increasing rate of the inductance to number of turns of the embodiment of the present invention is under about 1/3 of the prior art. Therefore, as has been elucidated in the above, in the microwave apparatus 1 of the present embodiment, it is possible to reduce the turns influence in comparison with that of the conventional microwave apparatus 100.

SECOND EMBODIMENT

FIG.7 is an enlarged explanatory view showing LC

FIG.7 is an enlarged explanatory view showing LC filter means of a second embodiment of the microwave apparatus of the present invention. In this second embodiment, the same components and parts as those of the first embodiment are designated by the same numerals, and corresponding descriptions similarly apply. Therefore, the descriptions will be made mainly on the modified parts from the first embodiment.

Gist of the second embodiment is to insert members, for example, bar-shaped ferrite cores 25a, 25b having a property of absorbing the high frequency radiation into the inside spaces of the coil-shaped parts 18a', 18b', respectively.

Thereby, it is possible to reduce the external leakage of the high frequency radiation further than with the first embodiment.

THIRD EMBODIMENT

FIG.8 is an enlarged explanatory view showing LC filter means of a third embodiment of the microwave apparatus of the present invention. In this third embodiment, the same components and parts as those of the first embodiment are designated by the same numerals, and corresponding descriptions similarly apply. Therefore, the descriptions will be made mainly on the modified parts from the first embodiment.

Gist of the third embodiment is to connect choke cathode terminals 12a, 12b (FIG.2) and the conductors 18a, 18b of the LC filter means 17, respectively.

Thereby, it is possible to reduce the external leakage of the high frequency radiation in comparison with the first embodiment.

FOURTH EMBODIMENT

FIG.9 is an enlarged explanatory view showing LC filter means of a fourth embodiment of the microwave apparatus of the present invention. In this fourth embodiment, the same components and parts as those of the first embodiment are designated by the same numerals, and corresponding descriptions similarly apply. Therefore, the descriptions will be made mainly on the modified parts from the first embodiment.

Gist of this fourth embodiment is to alternately form plural coating parts 27a, 27b (for example, 3 pieces) of the conductive layers 20a, 20b and plural non-coating parts 28a, 28b (for example, 2 pieces) of the conductive layers 20a, 20b in longitudinal directions of the coil-shaped parts 18a', 18b', respectively. That is, as shown in FIG.9, the conductive layers 20a, 20b are formed on the outer surfaces of the insulating layers 19a, 19b intermittently in a manner that stripes are formed on the outer surfaces of the insulating layers 19a, 19b by alternating appearance of the coating parts 27a, 27b shown by chain lines and the non-coating parts 28a, 28b.

In this fourth embodiment, some parts of the inductances and the capacitances appear at each of the coating parts 27a, 27b, and rest of the inductances appear at each of the non-coating parts 28a, 28b. Thereby, the predetermined capacitances are divided into three components appearing at the respective coating parts 27a, 27b, and also the predetermined inductances are divided into five components appearing at the respective coating parts 27a, 27b and the respective non-coating parts 28a, 28b. According to the inventor's experimental study, this divided inductance and divided capacitance type configuration makes possible to shorten the lengths of the coil-shaped parts 18a', 18b' in comparison with the first embodiment.

Also the experiments showed that in order to further shorten the lengths of the coil-shaped parts 18a', 18b', a range of the coating parts 27a, 27b shown by "X" becomes larger than, preferably about two times as large as, a range of non-coating parts 28a, 28b shown by "Y".

Apart from the aforementioned explanation, wherein the plural coating parts 27a, 27b and the plural non-coating parts 28a, 28b are formed alternately in longitudinal directions of the coil-shaped parts 18a', 18b', respectively, an alternative construction may be such that the plural coating parts 27a, 27b and the plural non-coating parts 28a, 28b are formed alternately so as to non-coating parts 28a, 28b are formed alternately so as to make stripes which are parallel with the axes of the coil-shaped parts 18a', 18b', respectively. Furthermore, the plural coating parts 27a, 27b and the plural non-coating parts 28a, 28b may be formed alternately in oblique manner of the axes of coil-shaped parts 18a', 18b', respectively, so that each of the plural coating parts 27a, 27b and each of the plural non-coating parts 28a, 28b is formed in a spiral shape.

Although the present invention has been described in terms of the presently preferred embodiments, it is to be understood that such disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the art after having read the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

Claims

1. A microwave apparatus comprising:
a microwave generating source,
LC filter means (7) for preventing external leakage of high frequency radiation from said microwave generating source, said LC filter means (17) having at least one coil-shaped conductor wire (18a', 18b'), an insulating layer (19a, 19b) formed on at least a part of the outer surface of said coil-shaped conductor wire (18a', 18b'), and a conductive layer (20a, 20b) formed on at least a part of the outer surface of said insulating layer (19a, 19b).
(FIG.s 1 --- 3, 7 --- 9)

2. A microwave apparatus in accordance with claim 1, wherein one end of said coil-shaped conductor wire (18a', 18b') is substantially electrically connected to a cathode terminal (12a, 12b), and the other end of said coil-shaped conductor wire (18a', 18b') is connected to a power source (5) for driving said magnetron (2), and said conductive layer (20a, 20b) is substantially electrically connected to a shielding metal case (16) and grounded.
(FIG.s 1 --- 3, 7 --- 9)

3. A microwave apparatus in accordance with claim 2, wherein pipe-shaped conductive member (21a, 21b) is fixed around said outer surface of said conductive layer (20a, 20b), and connected to said shielding metal case (16).
(FIG.s 1 ---3, 7 --- 9)

4. A microwave apparatus in accordance with any one of claims 1, 2 and 3, wherein member (25a, 25b) having a property of absorbing high frequency radiation is inserted into the inside space of said coil-shaped conductor wire (18a', 18b').
(FIG.7)

5. A microwave apparatus in accordance with claim 4, wherein choke coil (26a, 26b) having said member

(25a, 25b) is connected between said cathode terminal (12a, 12b) and said coil-shaped conductor wire (18a', 18b'). (FIG.8)

6. A microwave apparatus in accordance with any one of claims 1, 2, 3, 4, and 5, wherein said conductive layer (20a, 20b) is formed on the outer surface of said insulating layer (19a, 19b) intermittently to form on said outer surface of said insulating layer (19a, 19b) stripe of said conductive layer (20a, 20b). (FIG.9)

7. A microwave apparatus in accordance with claim 6, wherein said conductive layer (20a, 20b) is formed on the outer surface of said insulating layer (19a, 19b) intermittently in longitudinal direction of said coil-shaped conductor wire (18a', 18b'), and width of said conductive layer (20a, 20b) is larger than width of non existence region of said conductive layer (20a, 20b). (FIG.9)

8. A microwave apparatus in accordance with any one of claims 1, 2, 3, 4, 5, 6 and 7, wherein said coil-shaped conductor wire (18a', 18b') is of annealed copper wire, said insulating layer (19a, 19b) is of polyamide resin, and said conductive layer (20a, 20b) is of a silver paste. (FIG.s 1 --- 3, 7 --- 9)

9. A microwave apparatus in accordance with any one of claims 1, 2, 3, 4, 5, 6, 7 and 8, wherein thickness of said insulating layer (19a, 19b) is between 30 μm and 500 μm. (FIG.s 1 --- 3, 7 --- 9)

FIG.1

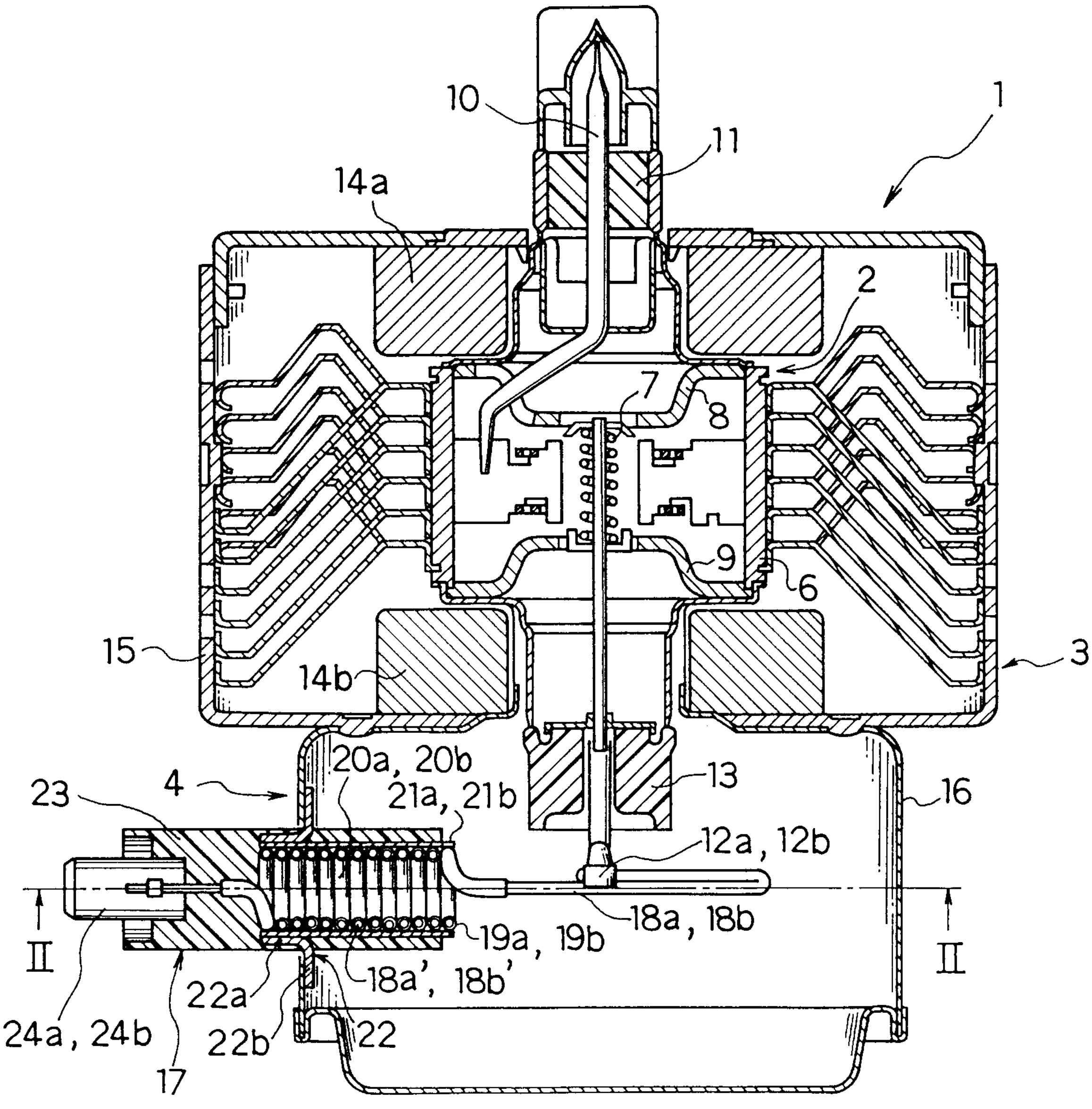
10
1
11
14a
2
7
8
9
6
15
3
14b
13
16
20a, 20b
4
23
21a, 21b
12a, 12b
18a, 18b
II
II
19a, 19b
18a', 18b'
22a
24a, 24b
22b
22
17

FIG. 2

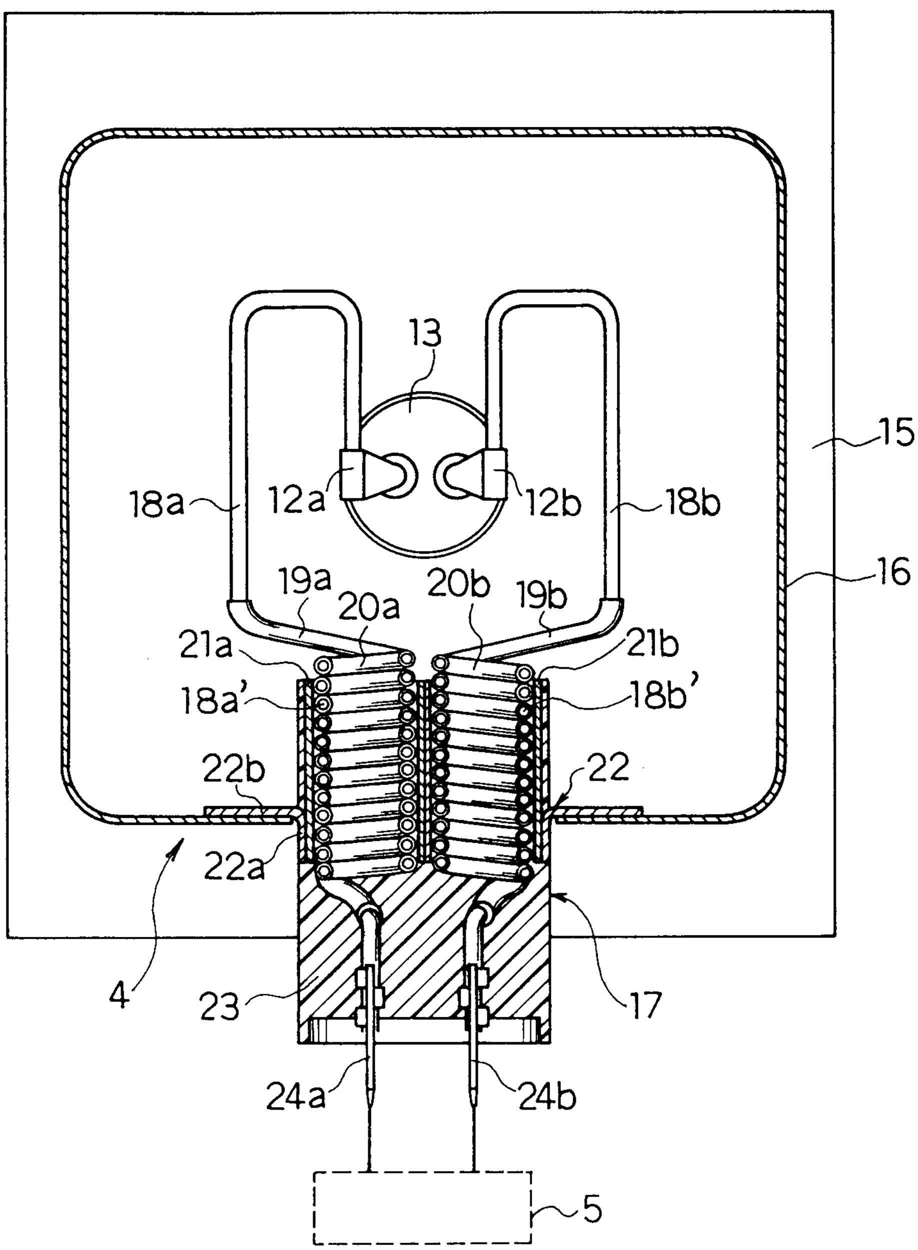
13
15
18a
12a
12b
18b
16
19a
20a
20b
19b
21a
21b
18a'
18b'
22b
22
22a
4
23
17
24a
24b
5

FIG. 3A

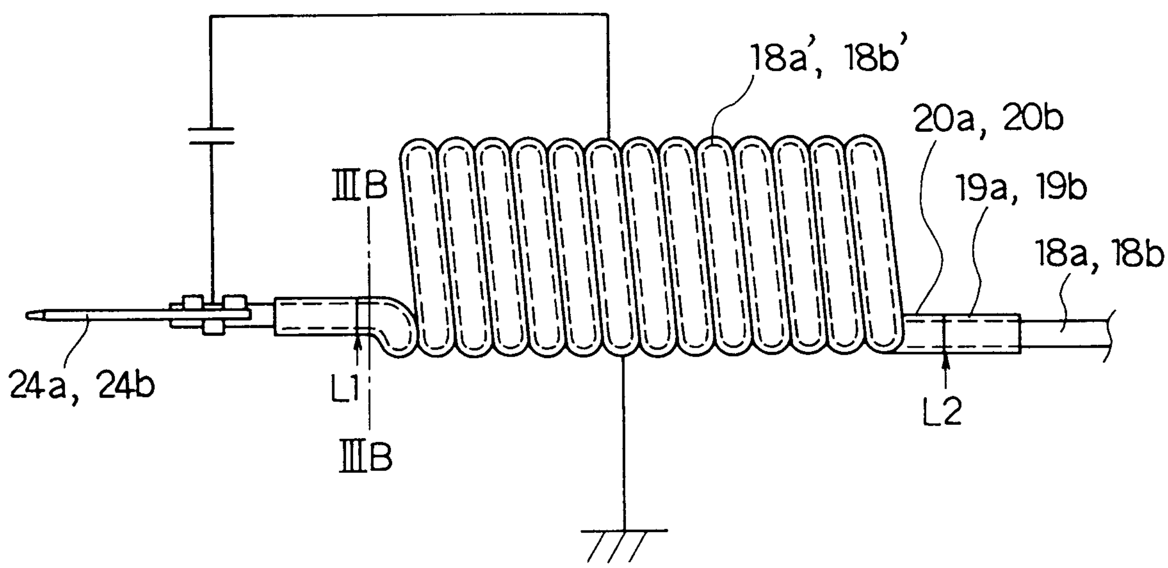
18a', 18b'
20a, 20b
19a, 19b
18a, 18b
ⅢB
24a, 24b
L1
ⅢB
L2

FIG. 3B

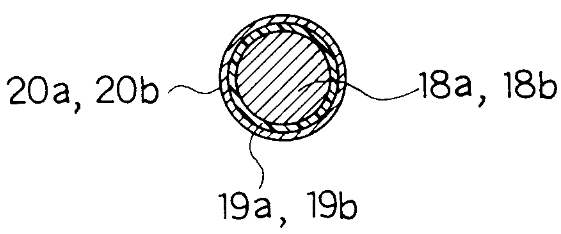
20a, 20b
18a, 18b
19a, 19b

FIG. 4A

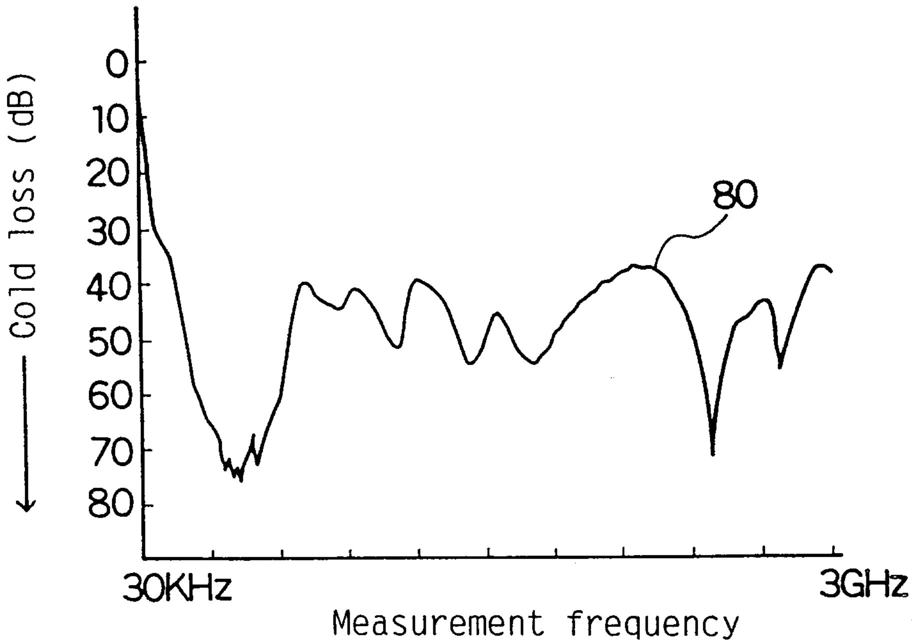
Cold loss (dB)
0
10
20
30
40
50
60
70
80
80
30KHz
3GHz
Measurement frequency

FIG. 4B

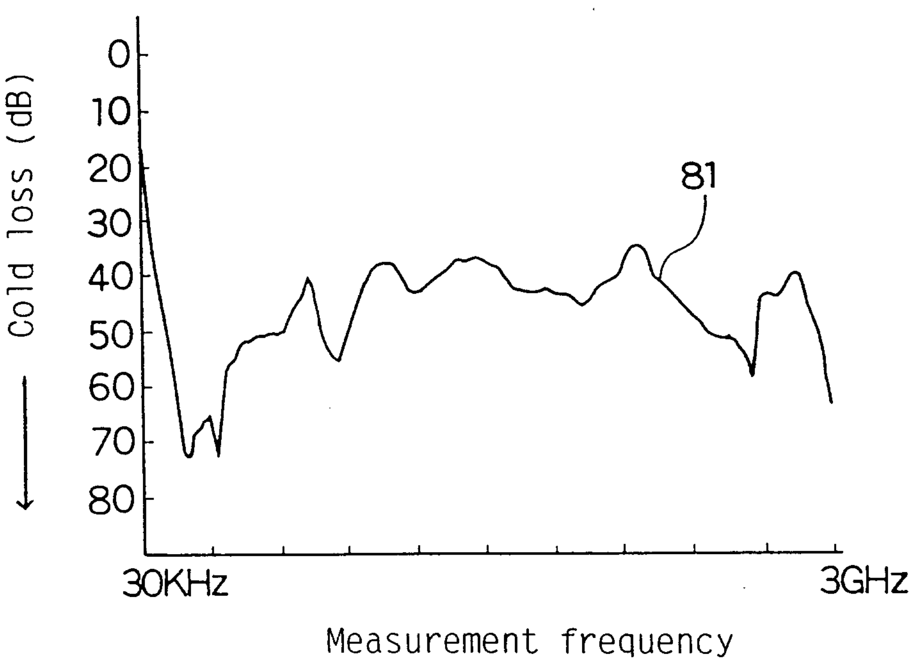
Cold loss (dB)
0
10
20
30
40
50
60
70
80
81
30KHz
3GHz
Measurement frequency

FIG. 5

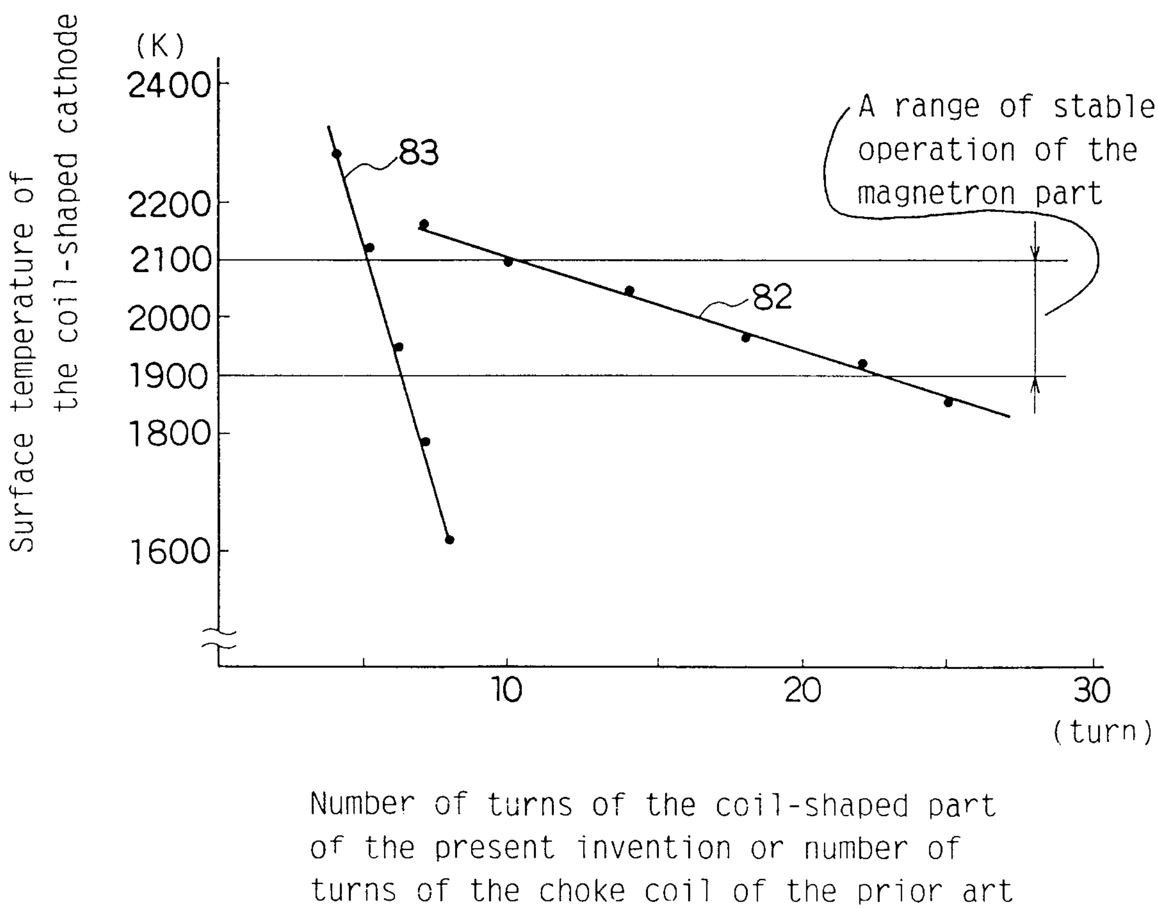
Surface temperature of the coil-shaped cathode
(K)
2400
2200
2100
2000
1900
1800
1600
83
82
A range of stable operation of the magnetron part
10
20
30
(turn)
Number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art

FIG. 6

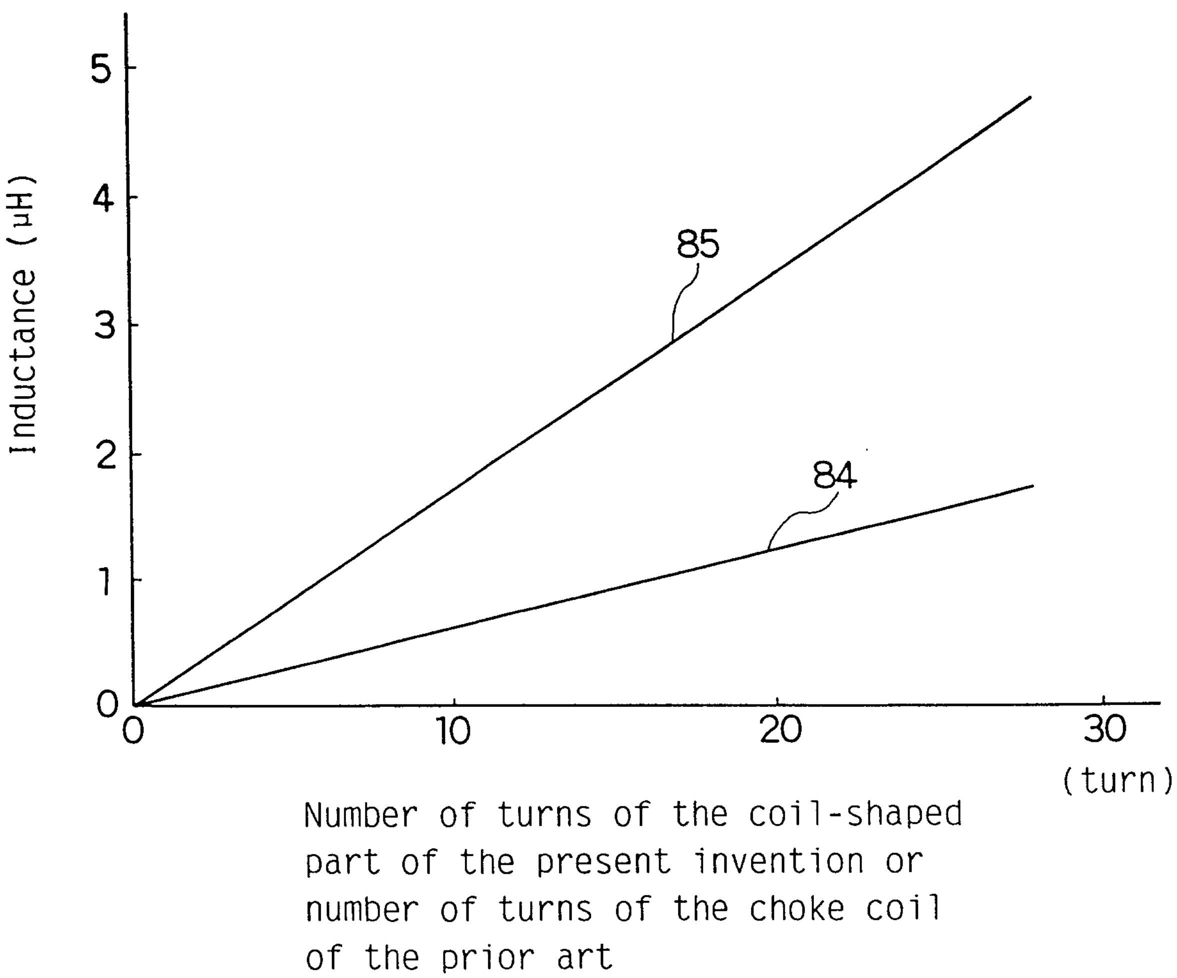
Inductance (μH)
5
4
3
2
1
0
85
84
0
10
20
30
(turn)
Number of turns of the coil-shaped part of the present invention or number of turns of the choke coil of the prior art

FIG. 7

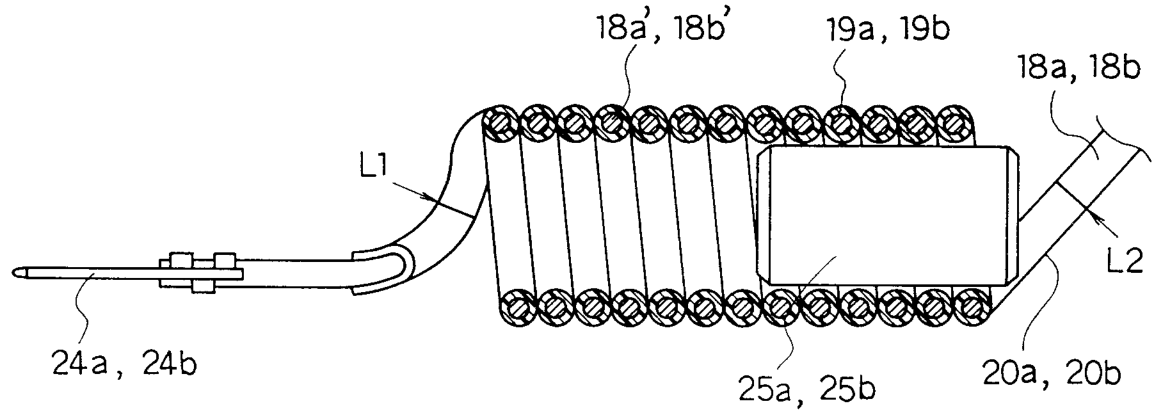

FIG. 8

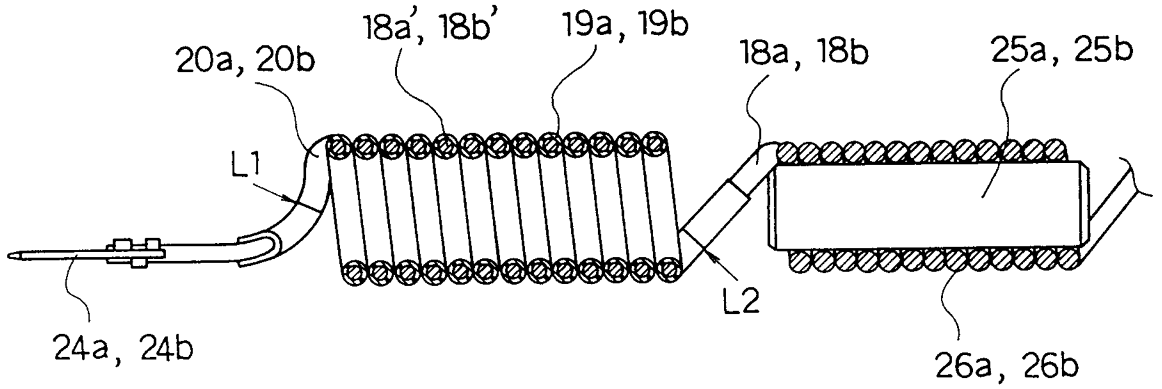

FIG. 9

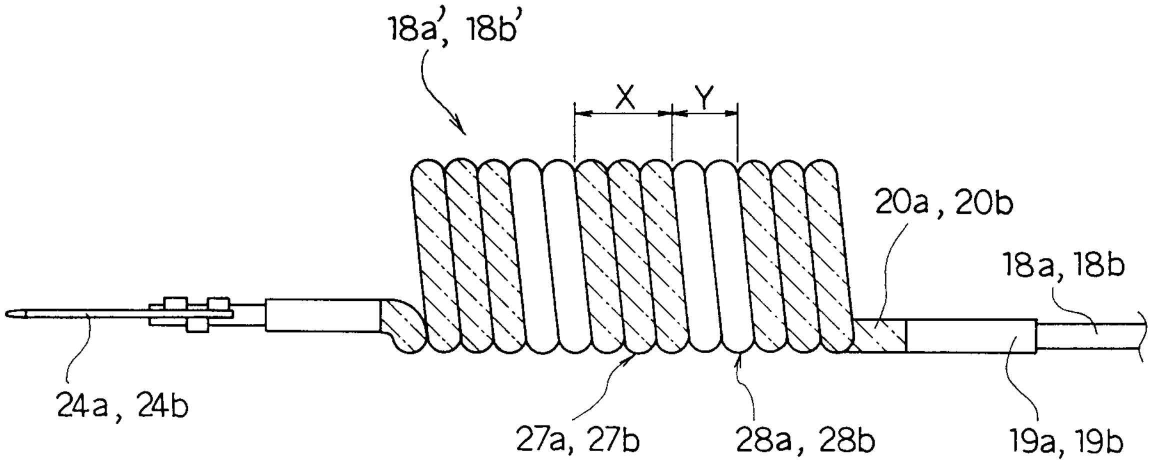

FIG. 10 (Prior Art)